PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
031/00469		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IL98/00172	08/04/1998	~~08/04/1998~~
International Patent Classification (IPC) or national classification and IPC		
G01H11/08		
Applicant		
KARMEL MEDICAL ACOUSTIC TECHNOLOGIES LTD et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☒ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
14/09/1999	11.07.2000
Name and mailing address of the international preliminary examining authority:	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Gerken, S Telephone No. +49 89 2399 6511

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IL98/00172

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-10	as originally filed			

Claims, No.:

1-31	as received on	09/06/2000	with letter of	07/06/2000

Drawings, sheets:

1/2,2/2	as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-31
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-31
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-31
	No:	Claims	

2. Citations and explanations

see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:
   D1: US-A-5 539 831 (HARLEY THOMAS R) 23 July 1996
   D2: ZUCKERWAR A J ET AL: 'DEVELOPMENT OF A PIEZOPOLYMER PRESSURE SENSOR FOR A PORTABLE FETAL HEART RATE MONITOR' IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, vol. 40, no. 9, 1 September 1993, pages 963-969, XP000448110

2. The invention relates to a device and a method for measuring sounds produced in a body and measured at the surface thereof in the presence of airborne sound.

3. The document D1, which is considered to represent the closest prior art, teaches (cf. Figs. 1 and 2 with related description) a device comprising a pair of sensors. A first of these sensors is placed on the surface of the body and receives sounds generated within the body and airborne sounds. The second sensor is placed at a location close to the first sensor and receives only the airborne sounds. Both sensors produce electrical signals. The signals are combined in an electronic circuit in such a manner that the relative amplitude of the signal responsive to airborne sounds is reduced.

4. The subject-matter of the independent **claims 1, 7, 25 and 26** differs therefrom essentially in that the sensors are mechanically or acoustically coupled internally in the device. In claim 26 this feature is expressed by the definition that *the second signal has a component responsive to the body sounds.*

5. The internal coupling allows to combine the signals of the first and second sensors such as to subtract the portions representing the airborne sound from each other and to add up the portions representing the body sounds. This results in an improved signal-to-noise ratio.

6. The differentiating feature indicated in paragraph 4. above is not known from or hinted at in the available prior art. In particular, D1 teaches away from the present

solution in that it prescribes that any internal coupling should be avoided (cf. col. 5, lines 18-23.) Hence, **claims 1, 7, 25 and 26** meet the requirements of novelty and inventive step, Art. 33(2) and (3) PCT.

7. The dependent **claims 2 - 6, 8 - 24 and 27 - 31** relate to preferred embodiments of the device or method of the independent claims to which they refer. The fulfil therefore also the requirement of novelty and inventive step, Art. 33(2) and (3) PCT.

Re Item VI

Certain documents cited

1. US-A-5,812,678 is cited under Rule 70.10 PCT with respect to all claims.

Re Item VII

Certain defects in the international application

1. The independent claims 1, 7 and 26 do not have the proper two-part form, with a preamble containing all the features that, in combination, are part of the closest prior art, which in this case appears to be given by the document D1 (Rule 6.3.b PCT).

2. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

3. The prior art which is considered to be relevant, i.e. the above-cited documents D1 and D2 have not been cited and briefly discussed in the opening part of the description (Rule 5.1.a.ii PCT).

CLAIMS

1. A device for detecting sounds generated within a body comprising:

a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and

airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

2. A device according to claim 1 wherein the second portion of said primary sensor signal is responsive to airborne sound which travels to said first sensor via said body.

3. A device according to claim 1 or claim 2 and including a secondary sensor which receives airborne sound and produces a secondary sensor signal wherein said airborne sound cancellation circuitry utilizes said secondary sensor signal to produce said output signal.

4. A device according to claim 3 wherein said secondary sensor signal comprises third and fourth portions responsive to said sounds generated within the body and said airborne sounds.

5. A device according to claims 3 or claim 4 wherein the cancellation circuitry combines a signal derived from the secondary sensor signal with a signal derived from the primary sensor signal in forming said output signal.

6. A device according to any of claims 3-5 wherein the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to increase said second ratio.

7. A device according to claim 6 wherein said equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals.

8. A device according to claim 6 wherein said equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

9. A device according to any of claims 6-8 and including equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

10. A device according to claim 9 an including a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value.

11. A device according to claim 10 wherein the thus produced airborne sound is essentially a single frequency sound.

12. A device according to claim 10 wherein the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

13. A device according to any of claims 3-12 wherein the primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces said primary sensor output responsive to deformations of the primary membrane.

14. A device according to claim 13 wherein the primary transducer is a piezoelectric element.

15. A device according to claim 13 or claim 14 wherein the secondary sensor comprises a secondary membrane and a secondary transducer, wherein the secondary transducer produces said secondary sensor signal responsive to deformations of the secondary membrane.

16. A device according to claim 15 wherein the secondary transducer is a piezoelectric element.

17. A device according to claim 15 or claim 16 wherein the secondary membrane is displaced from the first membrane.

18. A device according to any of claims 15-17 wherein the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

19. A device according to any of claims 15-18 wherein the secondary membrane is coated with a film to have a response similar to that of the human skin.

20. A device according to any of claims 15-18 wherein the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

21. A device according to any of claims 15-20 wherein the first and second sensors are mechanically or acoustically coupled such that vibrations of said primary membrane cause vibrations of the secondary membrane.

22. A device according to claim 21 wherein the coupling comprises a closed volume of gas and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

23. A device according to claim 21 wherein the coupling comprises a closed volume of liquid and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

24. A device according to any of claims 13-23 wherein the membrane is a metallic membrane.

25. A device according to claim 1 or claim 2 wherein the primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces said primary sensor output responsive to deformations of the primary membrane.

26. A device according to claim 25 wherein the primary transducer is a piezoelectric element.

27. A device according to any of claims 1, 2, 25 or 26 wherein the secondary sensor comprises a secondary membrane and a secondary transducer, wherein the secondary transducer produces said secondary sensor output responsive to deformations of the secondary membrane.

28. A device according to claim 27 wherein the secondary transducer is a piezoelectric element.

29. A device according to claim 27 or claim 28 wherein the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

30. A device according to claim 27 or claim 28 wherein the secondary member is coated with a membrane having a response similar to that of the human skin.

31. A device according to any of claims 27-30 wherein the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

32. A device for measurement of sounds conducted from the interior of the body to its surface in the presence of airborne sounds conducted through the body comprising:

a primary sensor comprising a primary membrane and a primary transducer, wherein the primary transducer produces a primary sensor output signal responsive to deformations of the primary membrane;

a secondary sensor comprising a secondary membrane and a secondary transducer, wherein the secondary transducer produces a secondary sensor output signal responsive to deformations of the secondary membrane; and

airborne sound cancellation circuitry which combines a signal derived from said secondary sensor output signal from a said primary output signal to produce an output signal having a reduced component responsive to the airborne sound.

33. A device according to claim 32 wherein the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to reduce the component responsive to the airborne sound.

34. A device according to claim 33 wherein said equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals.

35. A device according to claim 34 wherein said equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

36. A device according to any of claims 33-35 and including equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

37. A device according to claim 36 and including a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value.

38. A device according to claim 37 wherein the thus produced airborne sound is essentially a single frequency sound.

39. A device according to claim 38 wherein the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

40. A method of detecting sounds generated in a body in the presence of airborne sounds comprising:

placing a device according to any of the preceding claims against the body; and

producing an output signal.

41. A method of reducing the effect of airborne sound on a measurement of sounds produced in a body and measured at the surface thereof comprising:

providing a signal responsive to sound produced in the body and measured at the surface of the body and contaminated by a signal responsive to said airborne sounds;

providing a second signal having at least a component responsive to said airborne sounds; and

processing the first signal utilizing the second signal to produce an output signal having a reduced the relative amplitude of the signal responsive to airborne sounds.

42. A method according to claim 41 wherein providing a second signal comprises providing a second signal having a component responsive to sound produced in the body wherein the relative polarity of the signals responsive to the airborne and body produced sound is different for the second signal as compared to the first signal.

43. A method according to claim 41 or claim 42 and including adjusting at least one of the first and second signals to further reduce the relative amplitude of the signal responsive to the airborne sounds.

44. A method according to claim 43 wherein said adjustment is determined during a calibration stage comprising:

placing a device providing the first and second signals on the body in a position at which such measurement is to be made;

providing an airborne audio signal;

adjusting at least one of the first and second signals to minimize the response of the output signal to said provided airborne signal; and

utilizing said adjustment when measuring body sounds.

45. A method according to claim 44 wherein the adjustment is frequency insensitive.

46. A method according to claim 45 wherein the adjustment varies with frequency.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

FENSTER, Paul
Fenster & Company Patent Attorneys,
P.O. Box 10256
49002 Petach Tikva
ISRAEL

RECEIVED
19 -07- 2000
FENSTER & Co.

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	11.07.2000
Applicant's or agent's file reference 031/00469	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IL98/00172	08/04/1998	08/04/1998

Applicant
KARMEL MEDICAL ACOUSTIC TECHNOLOGIES LTD et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	DEL FRATE, A Tel.+49 89 2399-2413

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
031/00469		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IL98/00172	08/04/1998	08/04/1998
International Patent Classification (IPC) or national classification and IPC G01H11/08		
Applicant KARMEL MEDICAL ACOUSTIC TECHNOLOGIES LTD et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☒ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
14/09/1999	11.07.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Gerken, S Telephone No. +49 89 2399 6511

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IL98/00172

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-10	as originally filed				

Claims, No.:

1-31	as received on	09/06/2000	with letter of	07/06/2000	

Drawings, sheets:

1/2,2/2	as originally filed				

2. The amendments have resulted in the cancellation of:

☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-31
	No:	Claims
Inventive step (IS)	Yes:	Claims 1-31
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1-31
	No:	Claims

2. Citations and explanations

see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:
   D1: US-A-5 539 831 (HARLEY THOMAS R) 23 July 1996
   D2: ZUCKERWAR A J ET AL: 'DEVELOPMENT OF A PIEZOPOLYMER PRESSURE SENSOR FOR A PORTABLE FETAL HEART RATE MONITOR' IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, vol. 40, no. 9, 1 September 1993, pages 963-969, XP000446110

2. The invention relates to a device and a method for measuring sounds produced in a body and measured at the surface thereof in the presence of airborne sound.

3. The document D1, which is considered to represent the closest prior art, teaches (cf. Figs. 1 and 2 with related description) a device comprising a pair of sensors. A first of these sensors is placed on the surface of the body and receives sounds generated within the body and airborne sounds. The second sensor is placed at a location close to the first sensor and receives only the airborne sounds. Both sensors produce electrical signals. The signals are combined in an electronic circuit in such a manner that the relative amplitude of the signal responsive to airborne sounds is reduced.

4. The subject-matter of the independent **claims 1, 7, 25 and 26** differs therefrom essentially in that the sensors are mechanically or acoustically coupled internally in the device. In claim 26 this feature is expressed by the definition that *the second signal has a component responsive to the body sounds.*

5. The internal coupling allows to combine the signals of the first and second sensors such as to subtract the portions representing the airborne sound from each other and to add up the portions representing the body sounds. This results in an improved signal-to-noise ratio.

6. The differentiating feature indicated in paragraph 4. above is not known from or hinted at in the available prior art. In particular, D1 teaches away from the present

solution in that it prescribes that any internal coupling should be avoided (cf. col. 5, lines 18-23.) Hence, **claims 1, 7, 25 and 26** meet the requirements of novelty and inventive step, Art. 33(2) and (3) PCT.

7. The dependent **claims 2 - 6, 8 - 24 and 27 - 31** relate to preferred embodiments of the device or method of the independent claims to which they refer. The fulfil therefore also the requirement of novelty and inventive step, Art. 33(2) and (3) PCT.

Re Item VI

Certain documents cited

1. US-A-5,812,678 is cited under Rule 70.10 PCT with respect to all claims.

Re Item VII

Certain defects in the international application

1. The independent claims 1, 7 and 26 do not have the proper two-part form, with a preamble containing all the features that, in combination, are part of the closest prior art, which in this case appears to be given by the document D1 (Rule 6.3.b PCT).

2. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

3. The prior art which is considered to be relevant, i.e. the above-cited documents D1 and D2 have not been cited and briefly discussed in the opening part of the description (Rule 5.1.a.ii PCT).

CLAIMS

1. A device for detecting sounds generated within a body comprising:

a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and

a secondary sensor mechanically or acoustically coupled to the first sensor internally in the device, which receives said first sound vibrations via said coupling and which receives said second vibrations directly from the air in addition to any such vibrations received via the coupling and which generates a secondary electrical sensor signal in response thereto comprised of first and second portions in a second ratio different from said first ratio; and

airborne sound cancellation circuitry which receives the first and second signals and produces an output signal comprised of first and second portions, in a third ratio higher than said first ratio in response to said first and second signals.

2. A device according to claim 1 wherein the second portion of said primary sensor signal is arranged such that it is responsive to airborne sound which travels to said primary sensor via said body.

3. A device according to any of the preceding claims wherein the primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces said primary sensor output responsive to deformations of the primary membrane.

4. A device according to claim 3 wherein the primary transducer is a piezoelectric element.

5. A device according to any of the preceding claims wherein the secondary sensor comprises a secondary membrane and a secondary transducer, wherein the secondary transducer produces said secondary sensor signal responsive to deformations of the secondary membrane.

AMENDED SHEET

6. A device according to claim 5 wherein the secondary transducer is a piezoelectric element.

7. A device for measurement of sounds conducted from the interior of the body to its surface in the presence of airborne sounds conducted through the body comprising:

a primary sensor comprising a primary membrane and a primary transducer, wherein the primary transducer produces a primary sensor output signal responsive to deformations of the primary membrane;

a secondary sensor mechanically or acoustically coupled to the first transducer, internally to the device and comprising a secondary membrane and a secondary transducer, wherein the secondary transducer produces a secondary sensor output signal responsive to deformations of the secondary membrane; and

airborne sound cancellation circuitry which combines a signal derived from said secondary sensor output signal and a signal derived from said primary output signal to produce an output signal having a reduced component responsive to the airborne sound as compared with that present in said primary output signal.

8. A device according to claim 7, wherein when the device is placed on the body of a test subject,

the primary sensor receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and wherein the primary sensor signal is comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively;

the secondary sensor receives said first sound vibrations via said mechanical coupling and said second vibrations directly from the air in addition to any such vibrations received via the coupling such that said secondary electrical sensor signal is comprised of first and second portions in a second ratio different from said first ratio; and

the airborne sound cancellation circuitry produces an output signal comprised of first and second portions, in a third ratio higher than said first ratio in response to said first and second signals.

9. A device according to claim 7 or claim 8 wherein the primary sensor is a piezoelectric element.

AMENDED SHEET

10. A device according to any of claims 7-9 wherein the secondary transducer is a piezoelectric element.

11. A device according to any of the preceding claims wherein the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to reduce the component in the output signal that is responsive to the airborne sound.

12. A device according to claim 11 wherein said equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals.

13. A device according to claim 12 wherein said equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

14. A device according to any of claims 11-13 and including equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

15. A device according to claim 14 and including a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value.

16. A device according to claim 15 wherein the thus produced airborne sound is essentially a single frequency sound.

17. A device according to claim 16 wherein the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

18. A device according to any of claims 5-17 wherein the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

19. A device according to any of claims 5-18 wherein the secondary membrane is coated with a film to have a response similar to that of the human skin.

20. A device according to any of claims 5-18 wherein the secondary membrane is of a different thickness than the primary membrane to reduce the response of the secondary sensor to airborne signals.

21. A device according to any of claims 5-20 wherein the mechanical or acoustical coupling causes vibrations of the primary membrane to induce vibrations of the secondary membrane.

22. A device according to claim 21 wherein the coupling comprises a closed volume of gas and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

23. A device according to claim 21 wherein the coupling comprises a closed volume of liquid and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

24. A device according to any of claims 3-23 wherein the membrane is a metallic membrane.

25. A method of detecting sounds generated in a body in the presence of airborne sounds comprising:

placing a device according to any of the preceding claims against the body, such that the first sensor contacts the body; and

producing an output signal.

26. A method of reducing the effect of airborne sound on a measurement of sounds produced in a body and measured at the surface thereof comprising:

providing a signal responsive to sound produced in the body and measured at the surface of the body and contaminated by a signal responsive to said airborne sounds;

providing a second signal having at least a component responsive to said airborne sounds and a component responsive to said body sounds; and

processing the first signal utilizing the second signal to produce an output signal having a reduced the relative amplitude of the signal responsive to airborne sounds as compared with the first signal.

27. A method according to claim 26 wherein providing a second signal comprises providing a second signal having a component responsive to sound produced in the body wherein the relative polarity of the signals responsive to the airborne and body produced sound is different for the second signal as compared to the first signal.

28. A method according to claim 26 or claim 27 and including adjusting at least one of the first and second signals to further reduce the relative amplitude of the signal responsive to the airborne sounds.

29. A method according to claim 28 wherein said adjustment is determined during a calibration stage comprising:

placing a device providing the first and second signals on the body in a position at which such measurement is to be made;

providing an airborne audio signal;

adjusting at least one of the first and second signals to minimize the response of the output signal to said provided airborne signal; and

utilizing said adjustment when measuring body sounds.

30. A method according to claim 29 wherein the adjustment is frequency insensitive.

31. A method according to claim 30 wherein the adjustment varies with frequency.

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
G01H 11/08, 1/00

A1

(11) International Publication Number: WO 99/53277

(43) International Publication Date: 21 October 1999 (21.10.99)

(21) International Application Number: PCT/IL98/00172

(22) International Filing Date: 8 April 1998 (08.04.98)

(71) Applicant *(for all designated States except US)*: KARMEL MEDICAL ACOUSTIC TECHNOLOGIES LTD. [IL/IL]; P.O. Box 393, 39554 Tirat Hacarmel (IL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: GAVRIELI, Noam [IL/IL]; Sinai Avenue 11A, 34331 Haifa (IL). FENSTER, Maier [IL/IL]; Brande Street 61, 49600 Petach Tikva (IL).

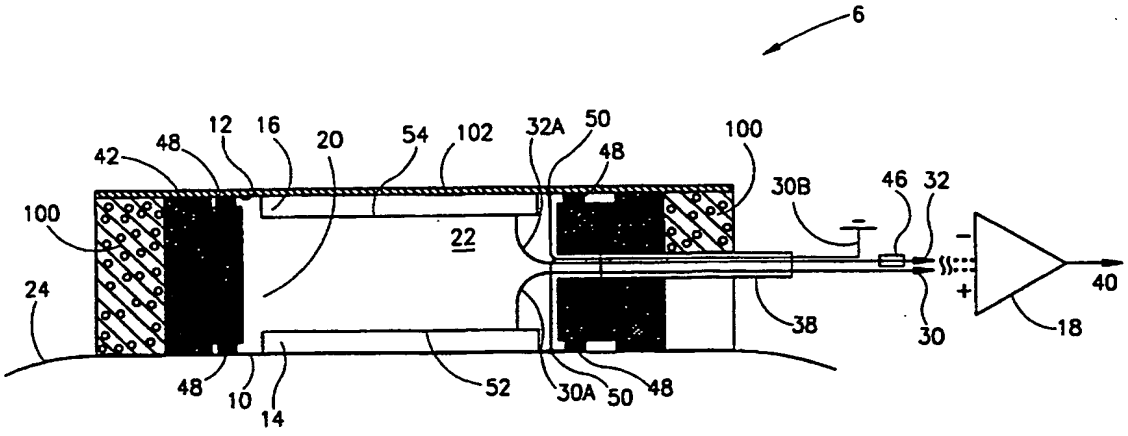
(74) Agents: FENSTER, Paul et al.; Fenster & Company, P.O. Box 2741, 49127 Petach Tikva (IL).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

With international search report.

(54) **Title:** SENSOR FOR BODY SOUNDS



(57) **Abstract**

A device for detecting sounds generated within a body including (1) a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and (2) airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
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BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
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BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
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BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 98/00172

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01H11/08 G01H1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01H A61B G01V B06B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 539 831 A (HARLEY THOMAS R) 23 July 1996 see abstract; claim 6; figures 1-3 see column 5, line 22 - line 24 see column 8, line 18 - line 20 see the whole document ---	1-46
X	ZUCKERWAR A J ET AL: "DEVELOPMENT OF A PIEZOPOLYMER PRESSURE SENSOR FOR A PORTABLE FETAL HEART RATE MONITOR" IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, vol. 40, no. 9, 1 September 1993, pages 963-969, XP000448110	1-3, 13-17, 25-28, 32,33, 40,41,43
A	see figures 5-7 see the whole document ---	22,23
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 January 1999	22/01/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	De Bekker, R

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 832 762 A (JOHNSTON R ET AL) 3 September 1974 see abstract; figures 2,4-6 see column 10, line 5 - line 41	22,23
A	US 3 970 878 A (BERGLUND CARL O) 20 July 1976 see abstract; figures 8,11	22,23
E	US 5 812 678 A (RAINONE ADELE SCALISE ET AL) 22 September 1998 see abstract; figures 1-3,5	1-3,32, 40,41
X	WO 97 25598 A (SAGEM SA ;HOUSNI JAMAL (FR)) 17 July 1997 see abstract; claim 1; figure 2	1-3,32, 40,41
A	US 4 301 809 A (PINCHAK ALFRED C) 24 November 1981 see abstract see column 1, line 18 - line 22	1,22,23
A	WO 95 14845 A (NORSKE STATS OLJESELSKAP ;KROKSTAD ASBJOERN (NO); MJAALAND SVEIN () 1 June 1995 see abstract; claim 1; figure 7	22,23

INTERNATIONAL SEARCH REPORT

Information on patent family members

tional Application No
PCT/IL 98/00172

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5539831 A	23-07-1996	US 5610987 A	11-03-1997
US 3832762 A	03-09-1974	CA 991305 A	15-06-1976
		DE 2326064 A	06-12-1973
		FR 2185800 A	04-01-1974
		GB 1435125 A	12-05-1976
		JP 49043680 A	24-04-1974
		NL 7307136 A	26-11-1973
US 3970878 A	20-07-1976	GB 1525781 A	20-09-1978
		JP 1249497 C	25-01-1985
		JP 51122422 A	26-10-1976
		JP 59027150 B	03-07-1984
US 5812678 A	22-09-1998	NONE	
WO 9725598 A	17-07-1997	FR 2743420 A	11-07-1997
		EP 0873498 A	28-10-1998
US 4301809 A	24-11-1981	NONE	
WO 9514845 A	01-06-1995	NO 934224 A	24-05-1995
		AU 1124495 A	13-06-1995
		CA 2177148 A	01-06-1995
		GB 2298715 A,B	11-09-1996
		NL 9420038 T	02-09-1996

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
FENSTER & Company
PATENT ATTORNEYS
P.O. BOX 2741
49127 Petach Tikva
ISRAEL

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 22/01/1999
Applicant's or agent's file reference 031/00469	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/IL 98/00172	International filing date *(day/month/year)* 08/04/1998
Applicant KARMEL MEDICAL ACOUSTIC TECHNOLOGIES LTD et al.	

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicants's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Jacobus Constant

Form PCT/ISA/220 (January 1994)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
031/00469		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/IL 98/00172	08/04/1998	
Applicant		
KARMEL MEDICAL ACOUSTIC TECHNOLOGIES LTD et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (see Box I).

2. [ ] **Unity of invention is lacking** (see Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] Transcribed by this Authority

4. With regard to the **title,**
   - [X] the text is approved as submitted by the applicant
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   - [X] the text is approved as submitted by the applicant
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:
   Figure No. 2
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/IL 98/00172

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01H11/08 G01H1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01H A61B G01V B06B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 539 831 A (HARLEY THOMAS R) 23 July 1996 see abstract; claim 6; figures 1-3 see column 5, line 22 - line 24 see column 8, line 18 - line 20 see the whole document ---	1-46
X	ZUCKERWAR A J ET AL: "DEVELOPMENT OF A PIEZOPOLYMER PRESSURE SENSOR FOR A PORTABLE FETAL HEART RATE MONITOR" IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, vol. 40, no. 9, 1 September 1993, pages 963-969, XP000448110	1-3, 13-17, 25-28, 32,33, 40,41,43
A	see figures 5-7 see the whole document ---	22,23
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 January 1999	22/01/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	De Bekker, R

1

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 832 762 A (JOHNSTON R ET AL) 3 September 1974 see abstract; figures 2,4-6 see column 10, line 5 - line 41	22,23
A	US 3 970 878 A (BERGLUND CARL O) 20 July 1976 see abstract; figures 8,11	22,23
E	US 5 812 678 A (RAINONE ADELE SCALISE ET AL) 22 September 1998 see abstract; figures 1-3,5	1-3,32, 40,41
X	WO 97 25598 A (SAGEM SA ;HOUSNI JAMAL (FR)) 17 July 1997 see abstract; claim 1; figure 2	1-3,32, 40,41
A	US 4 301 809 A (PINCHAK ALFRED C) 24 November 1981 see abstract see column 1, line 18 - line 22	1,22,23
A	WO 95 14845 A (NORSKE STATS OLJESELSKAP ;KROKSTAD ASBJOERN (NO); MJAALAND SVEIN () 1 June 1995 see abstract; claim 1; figure 7	22,23

INTERNATIONAL SEARCH REPORT

rmation on patent family members

International Application No
PCT/IL 98/00172

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5539831 A	23-07-1996	US 5610987 A	11-03-1997
US 3832762 A	03-09-1974	CA 991305 A	15-06-1976
		DE 2326064 A	06-12-1973
		FR 2185800 A	04-01-1974
		GB 1435125 A	12-05-1976
		JP 49043680 A	24-04-1974
		NL 7307136 A	26-11-1973
US 3970878 A	20-07-1976	GB 1525781 A	20-09-1978
		JP 1249497 C	25-01-1985
		JP 51122422 A	26-10-1976
		JP 59027150 B	03-07-1984
US 5812678 A	22-09-1998	NONE	
WO 9725598 A	17-07-1997	FR 2743420 A	11-07-1997
		EP 0873498 A	28-10-1998
US 4301809 A	24-11-1981	NONE	
WO 9514845 A	01-06-1995	NO 934224 A	24-05-1995
		AU 1124495 A	13-06-1995
		CA 2177148 A	01-06-1995
		GB 2298715 A,B	11-09-1996
		NL 9420038 T	02-09-1996

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

FENSTER, Paul
Fenster & Company Patent
Attorneys, Ltd.
P.O. Box 10256
49002 Petach Tikva
ISRAËL

Date of mailing (day/month/year)
10 April 2000 (10.04.00)

Applicant's or agent's file reference
031/00469

IMPORTANT NOTIFICATION

International application No.
PCT/IL98/00172

International filing date (day/month/year)
08 April 1998 (08.04.98)

1. The following indications appeared on record concerning:

[X] the applicant [X] the inventor [ ] the agent [ ] the common representative

Name and Address
GAVRIELI, Noam
Sinai Avenue 11A
34331 Haifa
Israel

State of Nationality: IL
State of Residence: IL
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address
GAVRIELY, Noam
Sinai Avenue 11A
34331 Haifa
Israel

State of Nationality: IL
State of Residence: IL
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
Kari Huynh-Khuong

Telephone No.: (41-22) 338.83.38

Copy for the Elected Office (EO/US)

PCT/IL98/00172

ATENT COOPERATION TRL. .TY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

FENSTER, Paul
Fenster & Company Patent
Attorneys, Ltd.
P.O. Box 10256
49002 Petach Tikva
ISRAËL

Date of mailing (day/month/year)
20 October 1999 (20.10.99)

Applicant's or agent's file reference
031/00469

IMPORTANT NOTIFICATION

International application No.
PCT/IL98/00172

International filing date (day/month/year)
08 April 1998 (08.04.98)

1. The following indications appeared on record concerning:

[X] the applicant [X] the inventor [ ] the agent [ ] the common representative

Name and Address
FENSTER, Maier
Brande Street 61
49600 Petach Tikva
Israel

State of Nationality: IL
State of Residence: IL
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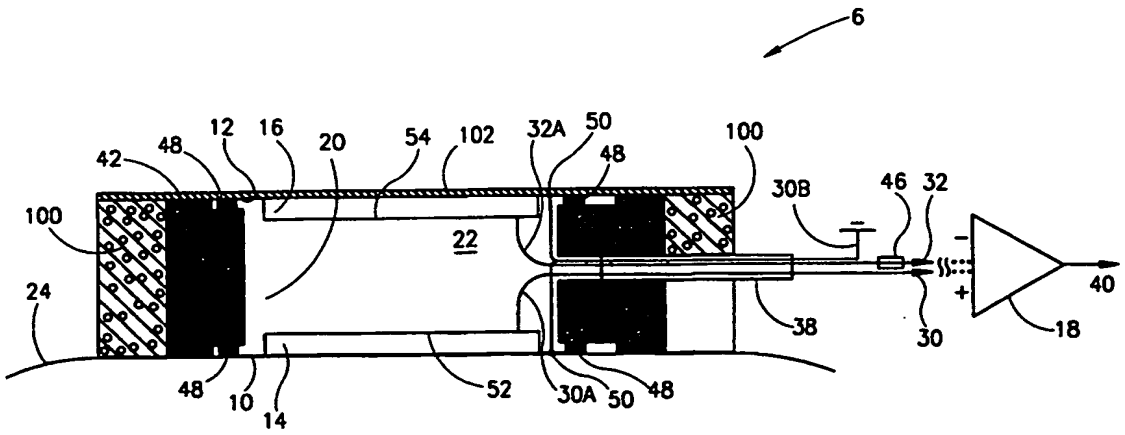

(57) Abstract

A device for detecting sounds generated within a body including (1) a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and (2) airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

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SENSOR FOR BODY SOUNDS

FIELD OF THE INVENTION

The present invention relates generally to sensors, and specifically to systems suitable for use in body sounds detection and analysis.

BACKGROUND OF THE INVENTION

The art of listening to body sounds, or auscultation, has been used by physicians for thousands of years, for diagnosing various diseases.

Auscultation was initially performed by placing the physician's ear directly on the skin of the patient. At the beginning of the 19th century, R.T. Laennec introduced a tool, the stethoscope, for transmitting of body sounds to the ear.

Currently used stethoscopes include a "chest piece" brought into contact with the patient's skin, and two flexible tubes, terminating in the physician's ears.

The use of various sensors which transform the shocks and vibrations produced by body sounds into electrical voltages is well known in the art. Various types of transducers have been used in implementing body sound sensors, including both air coupled and contact microphones or accelerometers.

Swedish patent 8702647-2 to Hök describes a contact microphone in which the vibrations of the body surface induce deformations of a piezoelectric transducer. Contact sensors using such a piezoelectric element are sensitive to electromagnetic noise caused by nearby AC power lines, by static electricity discharges or by nearby electric devices.

In general, sound detecting devices are made to reject shocks and vibrations induced by structure-borne sounds and detect induced by airborne sounds. Devices also exist which are made immune to airborne isotropic sound.

A sensor which detects only relative vibrations while rejecting non relative ones is described in US patent 5,456,116 to Lew. The sensor uses a piezoelectric transducer and a mechanical structure to differentiate the vibrations to be detected from those to be rejected.

US patent 5,335,282 to Cardas, describes a microphone for air conducted sound in which two or more transducers perform simultaneous measurements. Transducer outputs are summed such as to make this device substantially immune to shock and vibration.

Driving a transducer from opposite directions by airborne sounds has also been used to cancel noise. An example of such a device is an aircraft radio noise canceling microphone in which a transducer, driven from opposite directions substantially cancels airborne noise while not affecting directional sound.

SUMMARY OF THE INVENTION

It is an object of some of preferred embodiments of the invention to provide a sensor for detecting vibrations conducted to the sensor through a body, while rejecting airborne sounds such as speech. Preferably, vibrations to be detected are those caused by body sounds.

In accordance with a preferred embodiment of the invention, the sensor performs at least two measurements, where the relative polarity of the body sounds and the airborne sounds is different in the two measurements.

In accordance with a preferred embodiment of the invention, the measurements are performed by transducers. Preferably, the transducers are piezoelectric elements.

In accordance with a preferred embodiment of the invention, the piezoelectric elements are mechanically connected to membranes which vibrate in response to body and airborne sounds. Preferably, one of the membranes is in contact with the body.

Further, in accordance with a preferred embodiment of the invention, the membranes, preferably metallic, are mechanically coupled to each other, preferably by a gas or liquid.

In some preferred embodiments of the present invention, the output of transducers are combined, preferably by a differential amplifier, so that the airborne sounds are at least partly canceled.

In some preferred embodiments of the present invention, airborne sound reaches one of the membranes directly from surroundings, and reaches the other membrane through the body.

In some preferred embodiments of the present invention, the amplitude response to airborne sounds of the membrane receiving such sounds directly is adjusted so as to be as close as possible to the amplitude response to airborne sounds of the membrane in contact with the body.

In some preferred embodiments of the present invention, the adjustment of the amplitude response is made by mechanically loading the membrane facing the air, preferably by coating the membrane with a thin layer of a substance.

In some other preferred embodiments of the present invention, the amplitude response adjustment is made by an electrical trimmer and/or by utilizing weighted combination of the amplitude response of the two membranes when combining the outputs of the elements.

In some preferred embodiments of the present invention, the amplitude response adjustment is automatically performed to calibrate the sensor.

There is thus provided, in accordance with a preferred embodiment of the invention, a device for detecting sounds generated within a body comprising:

a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and

airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

Preferably, the second portion of said primary sensor signal is responsive to airborne sound which travels to said first sensor via said body.

In a preferred embodiment of the inventor the device includes a secondary sensor which receives airborne sound and produces a secondary sensor signal wherein said airborne sound cancellation circuitry utilizes said secondary sensor signal to produce said output signal. Preferably, the secondary sensor signal comprises first and second portions responsive to said sounds generated within the body and said airborne sounds.

In a preferred embodiment of the invention the cancellation circuitry combines a signal derived from the secondary sensor signal with a signal derived from the primary sensor signal in forming said output signal.

In a preferred embodiment of the invention, the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to increase said second ratio. Preferably, equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals. Alternatively, the equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

In a preferred embodiment of the invention, the device includes equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

In a preferred embodiment of the invention, the device a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value. In a preferred embodiment of the invention the thus produced airborne sound is essentially a single frequency sound. Alternatively, the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

In a preferred embodiment of the invention, the primary sensor comprises a primary membrane and a primary transducer and the primary transducer produces said primary sensor output responsive to deformations of the primary membrane. Preferably the primary transducer is a piezoelectric element.

Preferably, the secondary sensor comprises a secondary membrane and a secondary transducer and the secondary transducer produces said secondary sensor output responsive to deformations of the secondary membrane. Preferably, the secondary transducer is a piezoelectric element.

Preferably, the secondary membrane is displaced from the first membrane.

In a preferred embodiment of the invention the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

In a preferred embodiment of the invention the secondary member is coated with a membrane having a response similar to that of the human skin.

In a preferred embodiment of the invention, the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

In a preferred embodiment of the invention, the first and second sensors are mechanically or acoustically coupled such that vibrations of said primary membrane cause vibrations of the secondary membrane. Preferably, the coupling comprises a closed volume of gas or liquid and the primary and secondary membranes each form portions of an enclosure of the volume.

Preferably, the membrane is a metallic membrane.

There is further provided, in accordance with a preferred embodiment of the invention a device for measurement of sounds conducted from the interior of the body to its surface in the presence of airborne sounds conducted through the body comprising:

a primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces a primary sensor output signal responsive to deformations of the primary membrane;

a secondary sensor comprising a secondary membrane and a secondary transducer, wherein the secondary transducer produces a secondary sensor output signal responsive to deformations of the secondary membrane; and

airborne sound cancellation circuitry which combines a signal derived from said secondary sensor output signal from a said primary output signal to produce an output signal having a reduced component responsive to the airborne sound.

Preferably, the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to reduce the component responsive to the airborne sound. Preferably, the equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals. Alternatively the equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

In a preferred embodiment of the invention, the device includes equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound. Preferably the device includes a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value. In a preferred embodiment of the invention, the thus produced airborne sound is essentially a single frequency sound. Alternatively, the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

There is further provided, in accordance with a preferred embodiment of the invention a method of detecting sounds generated in a body in the presence of airborne sounds comprising:

placing a device according to preferred embodiments of the invention against the body; and

producing an output signal.

There is further provided, in accordance with a preferred embodiment of the invention, a method of reducing the effect of airborne sound on a measurement of sounds produced in a body and measured at the surface thereof comprising:

providing a signal responsive to sound produced in the body and measured at the surface of the body and contaminated by a signal responsive to said airborne sounds;

providing a second signal having at least a component responsive to said airborne sounds; and

processing the first signal utilizing the second signal to produce an output signal having a reduced the relative amplitude of the signal responsive to airborne sounds..

In a preferred embodiment of the invention, providing a second signal comprises providing a second signal having a component responsive to sound produced in the body wherein the relative polarity of the signals responsive to the airborne and body produced sound is reversed for the second signal as compared to the first signal.

In a preferred embodiment of the invention, the method includes adjusting at least one of the first and second signals to further reduce the relative amplitude of the signal responsive to the airborne sounds.

Preferably, the adjustment is determined during a calibration stage comprising:

placing a device providing the first and second signals on the body in a position at which such measurement is to be made;

providing an airborne audio signal;

adjusting at least one of the first and second signals to minimize the response of the output signal to said provided airborne signal; and

utilizing said adjustment when measuring body sounds.

In a preferred embodiment of the invention, the adjustment is frequency insensitive. Alternatively, the adjustment varies with frequency.

The present invention will be more clearly understood from the following description of the preferred embodiments of the invention taken together with the following drawings in which:

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 schematically shows the logic of operation and a cross-sectional view of the construction of a sensor, in accordance with a preferred embodiment of the present invention and

Fig. 2 schematically shows a cross-sectional view of the construction of a sensor in accordance with an alternative preferred embodiment of the invention and a preferred method of mounting the sensor.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 schematically depicts the logic of a sensor **6** in accordance with a preferred embodiment of the present invention. Sensor **6** comprises a pair of membranes **10** and **12**, a pair of transducers **14** and **16**, a combiner **18** and a housing **42** to which the membranes **10** and **12** are attached. A gas or liquid **22** fills enclosure **20** and mechanically couples membranes **10** and **12**. Use of different gases or liquids **22** will result in different mechanical coupling of membranes **10** and **12**.

When vibrating, membranes **10** and **12** transfer their vibrational energy to transducers **14** and **16** to which they are conductively glued. Transducers **14** and **16** transform this energy into another form, preferably electrical energy. Outputs **30** and **32** of transducers **14** and **16** are combined by combiner **18** and extracted from sensor **6** as a final output **40**.

Membranes and surfaces vibrate whenever sound or vibrations reach them, as for example surfaces **24** of a body **26** under the influence of body sounds **28** created inside body **26**. To detect vibrations induced by body sounds **28**, the surface of membrane **10** is brought into contact with surface **24**. For reasons of clarity the contact of membrane **10** and surface **24** is not shown in Fig. 1, however, they are shown in contact in Fig. 2 which is shows an alternative preferred embodiment of the invention. Vibrations induced by body sounds **28** which reach surface **24** (arrow **III**) are transmitted to membrane **10** by physical contact and then, through coupling medium **22**, to membrane **12** arrow (arrow **IV**). Airborne sounds **34** such as speech, are transmitted directly to membrane **12** (arrow **V**) and through body **26** (arrows **VI, VII**) to membrane **10**. The relative polarity of body and airborne vibrations received by membrane **10** (arrows **III** and **VII**) is different from the relative polarity of those vibrations received by membrane **12** (arrows **IV** and **V**). Combiner **18** combines outputs **30** and **32** so as to subtract the portion of the output generated by airborne sound **34** which reaches membranes **10, 12**, and to add the portion of the output generated by body sounds **28**. In a preferred embodiment of the invention, the amplitude of vibrations induced by airborne sound **34** in membrane **12** is controlled, as to match it as closely as possible to the amplitude of vibrations induced by airborne sound **34** in membrane **10** so that the amplitude response of the two transducers to airborne sounds is substantially the same. Airborne sound which may reach membrane **10** through the coupling medium does not affect the proper operation of a sensor built in accordance with this embodiment, because the amplitude of vibrations induced by airborne sound **34** in membrane **12** is matched as closely as possible to the algebraic sum of the amplitudes of airborne sound received at membrane **10** through the body and through coupling medium. Additionally or alternatively, the efficiency of coupling medium **22**, does not affect the proper operation of a sensor built in accordance with this embodiment, because, even if no body sound **28** can reach membrane **12**, cancellation of airborne sound in accordance with the above, will still be performed by controlling the amplitude of vibrations induced by airborne sound in membrane **12**, with no dependence on relative polarity of sounds detected by membranes **10** and **12**.

In a preferred embodiment of the invention, the amplitude of vibrations induced by airborne sound in membranes **10** and **12** is obtained by contacting membrane **12** with substance **36** which alters its amplitude response, preferably matching its response to that of the human skin. Alternatively or additionally, the response is altered by putting some distributed weights, (not shown), on the membrane. Alternatively or additionally, airborne sound **34** which reaches membranes **10, 12** in different directions, is electronically canceled by

weighted combination of outputs **30** and **32**. In a preferred embodiment of the present invention, algebraic addition of outputs **30** and **32** is performed in combiner **18** after the amplitude of output **32** is multiplied by a factor which matches it as closely as possible to the amplitude of part of output **30** related to airborne sound. Alternatively, the amplitude of output **32** is controlled by a trimmer **46** before it is combined with output **30**. It should be noted that to the extent that the response is matched mechanically, the system becomes relatively immune from electromagnetic interference.

Membranes **10** and **12**, preferably are thin metallic sheets made of stainless steel, preferably between 200 and 250 microns thick. The membranes are preferably conductively glued to transducers **14** and **16** and, at contact points **48**, to a preferably conductive sensor housing **42**. Transducers **14** and **16** are preferably piezoelectric crystals (PZT) although other transducers such as optical transducers may be used. Inner faces **52** and **54**, of PZTs **14** and **16** are respectively conductively connected to output wires **30A** and **32A**, while sensor housing **42** is grounded through wire **32B** at contact point **50**. Thus, the outer faces of transducers **14** and **16** are also grounded. Vibrations of membranes **10** and **12** induced by airborne sounds **34** in the directions of arrows **V** and **VII**, and by body sounds **28** in the direction of arrow **III** and **IV**, cause mechanical deformations on both PZT's which generate voltage difference between sensor housing **42**, and PZT's inner faces **54**, **52**. These voltage differences are of different polarity when related to airborne sounds, and of same polarity when related to body sounds. Electrical signals caused by the deformation of the PZTs are conducted through shielded, **38**, active wires **30A**, **32A** to combiner **18** which is preferably a differential amplifier.

Utilizing the above configuration, the part of outputs **30** and **32** related to airborne sounds **34** are canceled by differential amplifier **18**, while the part related to body sounds **28** is extracted as final output **40**.

In a preferred embodiment of the invention, the output of transducer **16** is additionally fed to a second operational amplifier (not shown), for use by breath sound equipment as an ambient noise detector.

As indicated above, in some of the preferred embodiments, the amplitude of vibrations induced by airborne sounds **34** in membrane **12** is matched to that induced in membrane **10** by contacting it with a substance **36**, preferably by coating or pasting a thin layer on membrane **12**. It has been found that a closed cell foam tape such as 3M type 1772 Foam Medical Tape with a thickness of 1.2 mm is suitable.

Alternatively or additionally, in some preferred embodiments, electronic adjustment of the amplitude of signals **30** and **32** is used. In these embodiments, trimmer **46** is adjusted to match the amplitude of the outputs of transducers **14** and **16** to airborne sounds.

In a preferred embodiment of the invention, the transducer **16** may be calibrated, in situ, to provide optimum cancellation of airborne sounds. In this embodiment, after placement of the sensor on the body, airborne sound is generated. This sound may be speech or other sound. Trimmer **46** or the relative gain of the channels of combiner **18** are varied to provide minimum signal, at **40**, from such sounds.

In a further preferred embodiment of the invention, alternative or additional to trimmer **46**, a servo controlled equalizer is used to equalize, at predetermined frequencies of the audio spectrum, the part of outputs **30** and **32** generated by airborne sounds. In this preferred embodiment of the invention airborne sound preferably at individual frequencies is generated, preferably corresponding to the center frequencies of bands of the equalizer. Circuitry receives the outputs generated in response to sound at the individual frequencies and changes the respective channel transmission of the equalizer until the output at **40** is minimized or eliminated.

Fig. **2** shows a sensor, in accordance with an alternative preferred embodiment of the invention, in which housing **42** is formed of a plastic material. For this embodiment membranes separate connection is preferably made to the outside surfaces of transducers **14** and **16**, preferably via membranes **10** and 12. In this case epoxy **48'** need not be conductive.

Fig. **2** also illustrates a preferred method of attaching the sensors of Figs. **1** or **2**. In this embodiment the sensor is surrounded by a sponge holding fixture **100** (which may be of the same material as forms the layer **36** of Fig. 1). The height of fixture **100** may be the same as or slightly less than that of housing **42**. Preferably fixture **42** is formed with a slit to allow for the easy removal of the sensor output cable shield **38** and the wires it contains. Fixture **100** is further formed with a sticky surface where it touches the skin of the subject such that it is securely, but removably attached thereto. In this preferred embodiment of the invention, a layer **102** of tape is preferably used to secure the fixture to the sensor. In a preferred embodiment of the invention, tape **102** is of the same material as described above with respect to the preferred embodiment of layer **36** of Fig. **1**. Thus, tape **102** provides the double function of securing the sensor and providing the desired loading of membrane **12**.

It is understood that the operation of a sensor in accordance with the logic and preferred embodiment of the present invention, is independent of the relative and absolute positioning of its constituent components. It is also understood that all the specific elements

described above are only representative of their functions, any other elements performing the same functions may be used in the construction of a sensor which acts in accordance with a preferred embodiment of the invention.

CLAIMS

1. A device for detecting sounds generated within a body comprising:

a primary sensor placed on the body which receives first sound vibrations caused by the sounds generated within the body and second sound vibrations caused by airborne sound and which generates a primary electrical sensor signal in response thereto comprised of first and second portions, in a first ratio, responsive to said first and second sound vibrations respectively; and

airborne sound cancellation circuitry which receives the first signal and produces an output signal comprised of first and second portions, in a second ratio higher than said first ratio, responsive to said first and second sound vibrations respectively.

2. A device according to claim 1 wherein the second portion of said primary sensor signal is responsive to airborne sound which travels to said first sensor via said body.

3. A device according to claim 1 or claim 2 and including a secondary sensor which receives airborne sound and produces a secondary sensor signal wherein said airborne sound cancellation circuitry utilizes said secondary sensor signal to produce said output signal.

4. A device according to claim 3 wherein said secondary sensor signal comprises third and fourth portions responsive to said sounds generated within the body and said airborne sounds.

5. A device according to claims 3 or claim 4 wherein the cancellation circuitry combines a signal derived from the secondary sensor signal with a signal derived from the primary sensor signal in forming said output signal.

6. A device according to any of claims 3-5 wherein the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to increase said second ratio.

7. A device according to claim 6 wherein said equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals.

8. A device according to claim 6 wherein said equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

9. A device according to any of claims 6-8 and including equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

10. A device according to claim 9 an including a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value.

11. A device according to claim 10 wherein the thus produced airborne sound is essentially a single frequency sound.

12. A device according to claim 10 wherein the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

13. A device according to any of claims 3-12 wherein the primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces said primary sensor output responsive to deformations of the primary membrane.

14. A device according to claim 13 wherein the primary transducer is a piezoelectric element.

15. A device according to claim 13 or claim 14 wherein the secondary sensor comprises a secondary membrane and a secondary transducer, wherein the secondary transducer produces said secondary sensor signal responsive to deformations of the secondary membrane.

16. A device according to claim 15 wherein the secondary transducer is a piezoelectric element.

17. A device according to claim 15 or claim 16 wherein the secondary membrane is displaced from the first membrane.

18. A device according to any of claims 15-17 wherein the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

19. A device according to any of claims 15-18 wherein the secondary membrane is coated with a film to have a response similar to that of the human skin.

20. A device according to any of claims 15-18 wherein the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

21. A device according to any of claims 15-20 wherein the first and second sensors are mechanically or acoustically coupled such that vibrations of said primary membrane cause vibrations of the secondary membrane.

22. A device according to claim 21 wherein the coupling comprises a closed volume of gas and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

23. A device according to claim 21 wherein the coupling comprises a closed volume of liquid and wherein the primary and secondary membranes each form portions of an enclosure of the volume.

24. A device according to any of claims 13-23 wherein the membrane is a metallic membrane.

25. A device according to claim 1 or claim 2 wherein the primary sensor comprises a primary membrane and a primary transducer, wherein the primary transducer produces said primary sensor output responsive to deformations of the primary membrane.

26. A device according to claim 25 wherein the primary transducer is a piezoelectric element.

27. A device according to any of claims 1, 2, 25 or 26 wherein the secondary sensor comprises a secondary membrane and a secondary transducer, wherein the secondary transducer produces said secondary sensor output responsive to deformations of the secondary membrane.

28. A device according to claim 27 wherein the secondary transducer is a piezoelectric element.

29. A device according to claim 27 or claim 28 wherein the secondary membrane is coated with a material to reduce the response of the secondary sensor to airborne signals.

30. A device according to claim 27 or claim 28 wherein the secondary member is coated with a membrane having a response similar to that of the human skin.

31. A device according to any of claims 27-30 wherein the secondary membrane is of a different thickness than the first membrane to reduce the response of the secondary sensor to airborne signals.

32. A device for measurement of sounds conducted from the interior of the body to its surface in the presence of airborne sounds conducted through the body comprising:

a primary sensor comprising a primary membrane and a primary transducer, wherein the primary transducer produces a primary sensor output signal responsive to deformations of the primary membrane;

a secondary sensor comprising a secondary membrane and a secondary transducer, wherein the secondary transducer produces a secondary sensor output signal responsive to deformations of the secondary membrane; and

airborne sound cancellation circuitry which combines a signal derived from said secondary sensor output signal from a said primary output signal to produce an output signal having a reduced component responsive to the airborne sound.

33. A device according to claim 32 wherein the cancellation circuitry comprises an equalizer which adjusts the amplitude of at least one of the primary sensor and secondary sensor signals to reduce the component responsive to the airborne sound.

34. A device according to claim 33 wherein said equalizer provides a frequency dependent adjustment to at least one of the primary and secondary signals.

35. A device according to claim 34 wherein said equalizer provides a frequency independent adjustment to at least one of the primary and secondary signals.

36. A device according to any of claims 33-35 and including equalizer adjustment circuitry which, in a calibration mode adjusts the equalizer to reduce the second portion of the output signal in response to an airborne sound.

37. A device according to claim 36 and including a sound generator which, during the calibration mode, produces an airborne sound and wherein said adjustment circuitry adjusts said equalizer circuitry to reduce the response of the device to a minimum value.

38. A device according to claim 37 wherein the thus produced airborne sound is essentially a single frequency sound.

39. A device according to claim 38 wherein the sound generator produces airborne sound at a plurality of frequencies in said calibration mode.

40. A method of detecting sounds generated in a body in the presence of airborne sounds comprising:

placing a device according to any of the preceding claims against the body; and

producing an output signal.

41. A method of reducing the effect of airborne sound on a measurement of sounds produced in a body and measured at the surface thereof comprising:

providing a signal responsive to sound produced in the body and measured at the surface of the body and contaminated by a signal responsive to said airborne sounds;

providing a second signal having at least a component responsive to said airborne sounds; and

processing the first signal utilizing the second signal to produce an output signal having a reduced the relative amplitude of the signal responsive to airborne sounds.

42. A method according to claim 41 wherein providing a second signal comprises providing a second signal having a component responsive to sound produced in the body wherein the relative polarity of the signals responsive to the airborne and body produced sound is different for the second signal as compared to the first signal.

43. A method according to claim 41 or claim 42 and including adjusting at least one of the first and second signals to further reduce the relative amplitude of the signal responsive to the airborne sounds.

44. A method according to claim 43 wherein said adjustment is determined during a calibration stage comprising:

placing a device providing the first and second signals on the body in a position at which such measurement is to be made;

providing an airborne audio signal;

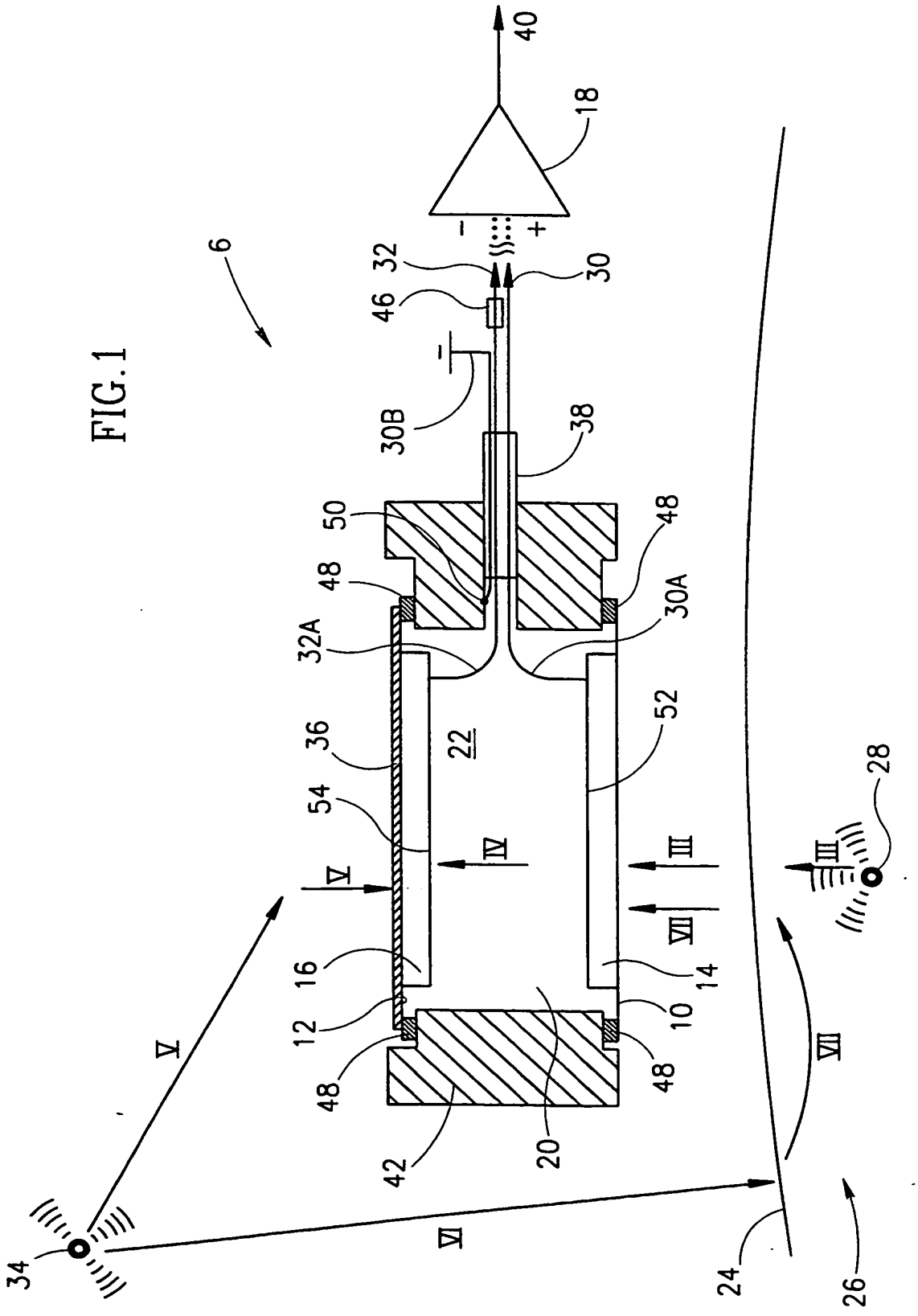
adjusting at least one of the first and second signals to minimize the response of the output signal to said provided airborne signal; and

utilizing said adjustment when measuring body sounds.

45. A method according to claim 44 wherein the adjustment is frequency insensitive.

46. A method according to claim 45 wherein the adjustment varies with frequency.

FIG.1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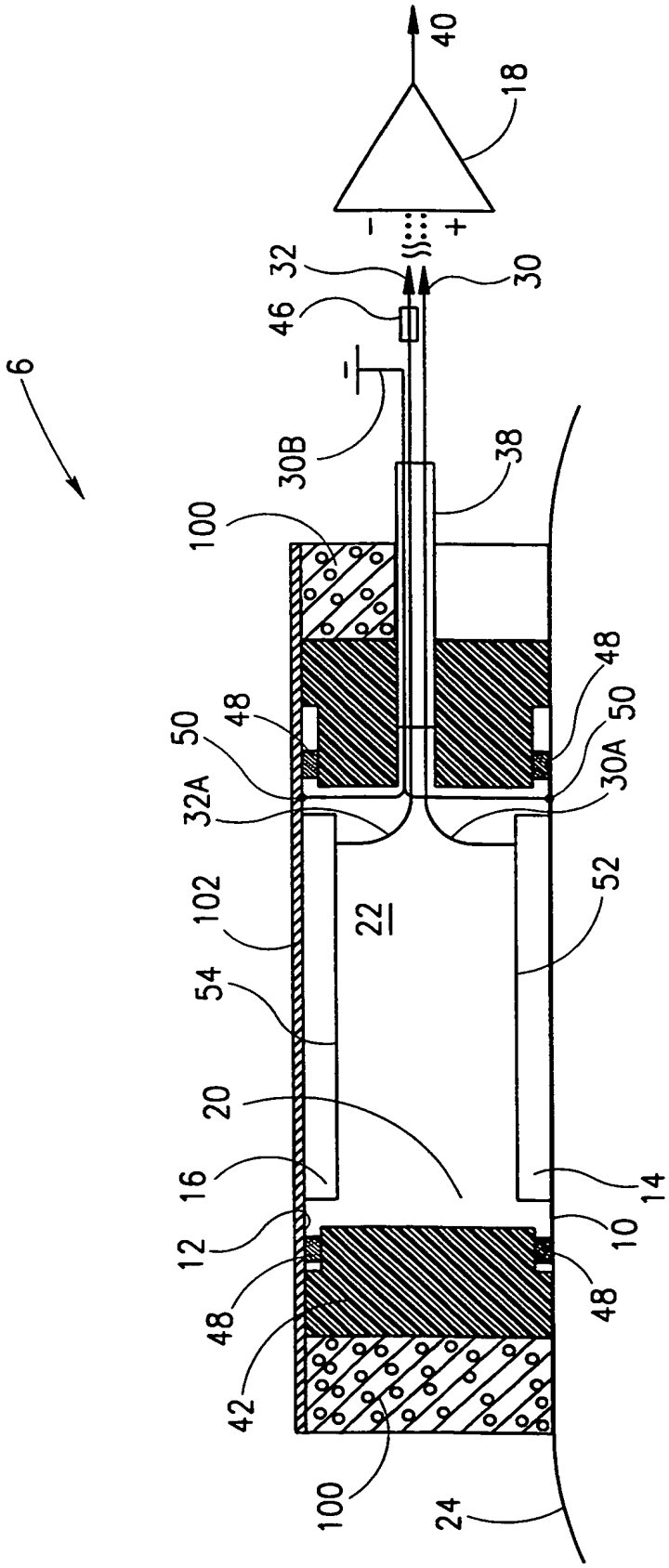
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FIG.2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 98/00172

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01H11/08 G01H1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01H A61B G01V B06B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 539 831 A (HARLEY THOMAS R) 23 July 1996 see abstract; claim 6; figures 1-3 see column 5, line 22 - line 24 see column 8, line 18 - line 20 see the whole document ---	1-46
X	ZUCKERWAR A J ET AL: "DEVELOPMENT OF A PIEZOPOLYMER PRESSURE SENSOR FOR A PORTABLE FETAL HEART RATE MONITOR" IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, vol. 40, no. 9, 1 September 1993, pages 963-969, XP000448110	1-3, 13-17, 25-28, 32,33, 40,41,43
A	see figures 5-7 see the whole document --- -/--	22,23

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 January 1999	22/01/1999

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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